of the oxygen. Water entering the first section of a raceway contains about 7 ppm dissolved oxygen (DO). Fish remove 2 ppm and the waterfall adds 1 ppm. The second section then receives 6 ppm DO, and so on. Water exiting the fourth and last section of a raceway contains about 3 ppm DO. As water flows down a ditch to the second set of raceways, DO is replenished to near saturation. The water, then, is reused and reused - five sets of raceways in all. The loss of DO can be calculated based on pounds of feed utilized. Ray calculated that the oxygen required to metabolize 50 pounds of feed is approximately 2 ppm from one CFS of water.

Approximately 0.2 ppm of ammonia is produced per CFS from metabolism of 50 pounds of feed. Feeding 200 pounds of feed in one CFS of water for four sections, ammonia at discharge would be 0.8 ppm. As water from the first set of raceways enters the ditch, bacteria begin to break ammonia down to nitrite, then the less harmful nitrate.

Settleable solids are a major concern for raceway growers, and the Environmental Protection Agency (EPA) stipulates that solids cannot exceed 5 ppm. In Ray's operation, solids collect behind a screen. A PVC stand-pipe is lifted periodically and solids go by underground pipe to two settling basins. These basins contain duckweed and aeration. The sludge is pumped to the fifth set of raceways containing tilapia.

With his raceway system, Ray annually produces 500,000 pounds of catfish. He does his own processing. If we assume that last year 300 million pounds of catfish were produced by the whole industry, then Ray's small raceways produce 1 out of every 600 catfish grown in the United States.

Not everyone, however, has access to gravity flow water year-round. Nevertheless, much can be learned from Ray's method of growing fish. He has demonstrated that raceway culture need not be limited to trout. The physical dimensions of his raceways, stocking density, reuse of water, and water management are all lessons to learn. And now one catfish farmer has built on Ray's technology. Kelley Farmer, pioneer catfish farmer from Dumas, Arkansas, is growing catfish in raceways. Water, held in a reservoir, flows by gravity through raceways, collects in a pond below and is pumped up to the reservoir for reuse. Too costly? The cost of pumping is more than offset by the savings in harvesting and other operations. Two of Ray's raceways with a total of eight sections can produce 80,000 pounds of fish per crop. If we assume that 4,000 pounds of fish are produced per acre in conventional ponds, it would take a 20-acre grow-out pond to produce 80,000 pounds. Will raceways be the way catfish and other species are grown in the future? Think about it.

Source: James W. Avault, "How Will Fish Be Grown in the Future," **Aquaculture Magazine**, Vol. 15, No. 1. January/February 1989.

## ARTIFICIAL REEFS CAN DO MORE HARM THAN GOOD

Artificial reefs (AR) can be found in many parts of the world. Japan is the pioneer and leading builder, followed by the United States. Japan has over 200 years of traditional and later sophisticated AR experience, while American anglers have used artificial reefs for more than 100 years.

In the US, the technique is popular mainly because it improves the catch of sports fishermen. This differs from the socioeconomic value of artificial reefs in southern Japan where emphasis is on development of coastal fisheries, extensive mariculture, and rehabilitation of degraded marine areas. The Philippines' AR program therefore should parallel that of tropical Japan from which it has much to gain in techniques, design, site selection, and other vital considerations.

Coastal resource enhancement for extensive mariculture and searanching has many advantages for an archipelagic country like the Philippines, including production on a sustainable-

***Artificial reefs should not be treated as "fun projects" by well-meaning but misinformed enthusiasts. Nor should they be employed as public relations gimmick to promote resource enhancement. This technology, if not properly used, can only do more harm than good.***

yield basis and greater social benefits to poor coastal communities. To achieve these, the country must develop and enrich near-shore fishing grounds through such mechanisms as appropriate applications of artificial reefs. **With its depleted coastal resources, the Philippines need artificial reefs not as a fishing device but as a fishery management tool.**

Tires or bamboo modules should be avoided because these only serve as fish aggregating devices which encourage overfishing. Furthermore, tires release toxic chemicals, bamboos easily deteriorate, both are unstable for habitat development and ultimately end up littering the ocean floor as what happened in Thailand.

The best approach presently held by most experts is to construct artificial reefs that will serve the intended purpose. The present scheme, using scrap materials to recreate the features of natural reefs. does not in fact improve the habitat conditions nor achieve the coastal enhancement it is supposed to promote. Thailand has already recognized this error, and has recently abandoned the use of tires in its four-year (1988-91) coastal enhancement program and adopted concrete modules instead.

An inhibiting factor is the cost of designed reefs. However, once all costs and benefits are identified and prorated over expected functions and life span of the regenerated reefs, this factor may not be as restrictive as it appears.

To achieve the success of the Japanese AR program, the Philippines should refrain from using a trial-and-error approach in design and site selection, especially in view of the high cost of materials involved. A careful study should be made both for the most cost-effective reef designs and suitable sites before large-scale implementation of this long-range program. Present scientific literature provides adequate information on how to correctly build and site artificial reefs. Right evaluation of designs, cost-benefit factors, and other parameters should be incorporated into the AR program. A planning team of engineers, marine scientists, and socioeconomists should be tasked to conduct this study.

There is too much publicity about the use of artificial reefs made of tires and bamboo. Artificial reefs should not be treated as "fun projects" by well-meaning but misinformed enthusiasts. Nor should they be employed as public relations gimmick to promote resource enhancement. This technology, if not properly used, can only do more harm than good.

The seriously depleted state of the country's fish resources demands an effective enhancement program that will restore fish stocks to a sustainable level. The present AR program is a step in this direction as it presumes to establish fish habitats that will increase fish biomass. However, the design and materials of local artificial reefs (scrap tires and bamboos) make them effective only in aggregating fishes but not in regenerating destroyed fish environment. Changing the design with high density, durability, and stability under water, therefore, would ensure permanent foundation for settling organisms that will be the basis for a food chain to support new fish populations. The primary aim is to rehabilitate degraded coastal fishing grounds which takes time. Thus the AR program must be planned along such long-term consideration.

The program also needs instituting catch regulations, as concrete reefs will also attract fishes. More forceful implementation of such regulations can only be done by coastal fishermen themselves, if organized into associations or cooperatives and granted exclusive territorial use rights over municipal waters.

Source: Excerpts from report prepared for then Dept. of Agriculture Secretary Carlos Dominguez. 22 August 1988. by Dr. Flor Lacanilao. Chief, SEAFDEC/AQD.